Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
The Establishment of Policies and	)	
Service Rules for the Non-Geostationary	)	IB Docket No. 01-96
Satellite Orbit, Fixed Satellite Service in the	)	
Ku Band	)	

COMMENTS OF TELEDESIC LLC

Teledesic submits these Comments in response to the Commission's Notice of Proposed Rulemaking ("NPRM") in the above-captioned proceeding.[1] The Notice sets forth a number of proposals that hold great promise for promoting spectrum sharing between NGSO FSS systems and encouraging deployment of new advanced services to the public using state-of-the-art technology.[2] Teledesic strongly supports the Commission's policy preference for allowing the service market rather than regulatory fiat to guide the development of service in this spectrum band. To this end Teledesic urges the Commission to adopt a spectrum-sharing policy that permits operators maximum flexibility to share spectrum frequency and coverage so long as they mitigate interference during in-line interference events. Teledesic also endorses the Commission's proposal to adopt blanket licensing of earth stations in the Ku-band NGSO

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[1] Notice of Proposed Rulemaking, FCC 01-134 (rel. May 3, 2001).

[2] Teledesic is pleased to comment on the proposals included in the NPRM. However, Teledesic looks forward to the opportunity to comment upon proposed rules to implement a spectrum sharing regime in a forthcoming Further Notice of Proposed Rulemaking in this proceeding. Because of the unusually technical nature of the proposals here, it is important that the sharing rules themselves – not just the general concepts – be published for public comment.

FSS spectrum bands without imposing antenna reference pattern requirements or off-axis equivalent isotropically radiated power ("e.i.r.p.") density limits.

I. Adoption of an "Avoidance of In-line Interference Events" Model Will Promote Flexible, Efficient, and Cooperative Use of Ku-Band Spectrum by NGSO FSS Systems

Teledesic urges the Commission to adopt a variation of its third spectrum sharing option – Avoidance of In-Line Interference Events – for the systems in the first Ku-band NGSO FSS processing round, as this model best accomplishes the three objectives of the Commission regarding inter-system sharing: 1) ensuring all applicants have equal access to spectrum; 2) preventing spectrum warehousing by non-implemented NGSO FSS systems; and 3) promoting cooperative sharing among system proponents. Teledesic's support for spectrum sharing based on avoidance of "in-line events" is premised on support for the Commission's identification of six NGSO spectrum sub-bands and recognition that in order to operate all licensees must have access to some portion of each of these six sub-bands.[3]

The third approach outlined in the NPRM, as understood by Teledesic, is more spectrum-efficient than Option 1 or 2, and will leave operators with much more design flexibility than Option 4. The in-line events model leaves all operators free to use all of the spectrum for as much of the time as possible, requiring coordination and mitigation measures only during in-line events. By contrast, Options 1 & 2, Flexible Band Segmentation and Dynamic Band Segmentation, decrease the amount of spectrum each operator can use, even when no interference would result from each system using the full band.

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[3] In the NPRM the Commission identifies three sub-bands in the NGSO FSS uplink spectrum allocation – 12.75-13.25 GHz, 13.75-14.0 GHz and 14.0-14.5 GHz – and three sub-bands in the downlink allocation – 10.7-11.7 GHz, 11.7-12.2 GHz and 12.2-12.7 GHz. *See* NPRM ¶ 17.

Furthermore, use of an in-line events model will not require operational systems to design and operate their systems around arbitrary spectrum assignments or expanding or contracting assignments based on the number of operational systems. Such flexibility will eliminate warehousing concerns because a lack of rigid spectrum assignments will avoid the necessity of Commission action to reassign spectrum when licensees fail to launch their proposed systems. An avoidance of in-line events model will also help NGSO FSS operators obtain landing rights around the world, because it will not constrain any operator to a small sub-band that may not be available in a particular country.

Teledesic agrees that homogeneous constellations could be a powerful tool for facilitating sharing between NGSO FSS systems. However, this should for the most part be regarded as a sharing technique rather than a realistic option for a Commission-imposed design standard. Imposing such a constraint on flexibility with respect to design and operation of NGSO FSS systems will only extend the timeline for launch of service and create another layer of negotiation on orbit type before service is even launched. Teledesic recognizes that the orbit proposed by Virtual Geosatellite, LLC has some unique properties, including the ability to share spectrum with GSO networks. In any case, Teledesic is of the view that the constellation proposed by Virtual Geosatellite, LLC can be appropriately accommodated within the in-line events model.

A. Definition of "In-Line" Events

Teledesic's support for an avoidance of in-line events model is based on the fact that operational NGSO FSS systems can share the same spectrum frequency and coverage so long as they avoid in-line interference events. In simple terms, given systems A and B, such an event occurs when a satellite from system B is aligned with the transmission path between an earth station and a satellite of system A. Such a transmission can be associated with either an earth-to-space or a space-to-earth path. Because interference can still be very severe for configurations close to the perfect alignment described above, an in-line event is broadly understood to include these other configurations as well. Such events would occur infrequently, particularly if only a few of the current seven systems actually become operational. Harmful interference from in-line events could be avoided altogether through coordination of all such NGSO FSS systems. During in-line events, coordination would lead to spectrum segmentation and/or satellite diversity.

Although Teledesic strongly supports the Commission's proposal to adopt an unambiguous technical definition of an in-line event and to premise this definition on a requirement that coordination for co-frequency operation be based on maximum allowable inter-network interference, Teledesic cautions against borrowing the definition of such events established in the GSO context. Coordination is triggered between GSO FSS systems only when the inter-network interference caused by the earth and space station emissions of any one network operating in the same frequency band or bands is greater than 6% of the total system noise power under clear-sky conditions.[4] Teledesic believes that the GSO FSS 6% total system noise trigger for coordination is inappropriate for NGSO FSS networks because of the time-varying nature of interference that may occur between two or more such systems. For GSO FSS systems the 6% trigger is compared to an interference that is present 100% of the time. However, for NGSO FSS systems if a 6% level of interference is exceeded only for a small percentage of time, this interference is likely to be acceptable. Actually, even higher levels

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[4] *See* NPRM ¶ 33.

of interference that occur only during a small fraction of the time may also be acceptable. This is so because the link margin used to combat fading will often be available and would then be able to accommodate (without link outage) an interference that, like the fading, is not present for most of the time. Therefore, a 6% trigger can lead to unnecessary coordination.

In keeping with the prevailing view in ITU-R studies conducted over the last six years and based on methodology outlined in the current text of ITU-R Recommendation S.1323-1, Teledesic proposes a different approach. ITU-R Recommendation S.1323-1 defines in its *recommends 3.1* the allowable aggregate short-term interference in a NGSO FSS system.[5] The current text of *recommends 3.1* defines an aggregate interference time allowance of 10% of the time allowance for the BER specified in the short-term performance objectives. However, the aggregate interference includes both GSO FSS and NGSO FSS interfering networks. More recently, Working Party 4A has agreed to a 10% allowance solely for NGSO interference (the same applying to GSO FSS systems).[6] This modification has not been yet formally introduced to Recommendation ITU-R S.1323-1 but has been endorsed in a U.S. contribution to the ITU-R Working Party 4A.[7] Teledesic proposes that a 10% aggregate allowance applicable to the interference from NGSO FSS systems be adopted.

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5 "Maximum Permissible Levels Of Interference In a Satellite Network (GSO/FSS; Non-GSO/FSS; Non-GSO/MSS Feeder Links) in the Fixed-Satellite Service Caused by Other Codirectional Networks Below 30 GHz," Recommendation ITU-R S.1323-1.

6 "Preliminary Draft Revision of Recommendation ITU-R S.1323-1", Revision 1 to Document 4A/TEMP/74 (May 1, 2001).

7 "Proposed Modifications to Draft Revision of Recommendation ITU-R S.1323", U.S. Submission to the September/October 2000 meeting of Working Party 4A, Document 4A/32 (September 18, 2000).

Under this proposed methodology, when only two systems are involved, single-entry interference will equal aggregate NGSO FSS interference. It is therefore proposed that an "in-line" event will occur whenever the 10% interference allowance is exceeded by any of the two systems. In Appendix 1, we provide a more detailed description of how this procedure can be implemented and how "in-line" events should be defined through avoidance angles as seen from earth stations or from satellites.

When three or more NGSO FSS systems are involved, the 10% aggregate interference still applies but it is highly desirable to define coordination triggers for each pair of systems. For example, if three systems are operational, exceeding the 10% allowance in one of the systems does not mean that coordination is required with both of the other systems. It may very well be the case that most of the interference is caused by one of the other two systems and, therefore, the third system should not be involved in the coordination.

Studies currently under way in ITU-R have addressed the issue of apportioning the 10% interference allowance among the several interfering NGSO FSS systems. No concluding results have been published to date although the current status of the work has been reported.[8] There is evidence that even for the small percentage of time associated with the short-term BER requirement, there is interference aggregation both in time and in power. In any case, it is always possible to express the single-entry requirement as a percentage of the time allowance for the BER specified in the short-term performance objectives. Tentatively and until ITU-R studies on the matter are concluded, Teledesic proposes a 7% time allowance when three systems are involved (two interfering sources) and a 5% time allowance when four or more

[8] "Further Work Toward a Definition of a Single-Entry Interference Criterion to Be Used During Coordination Between Two Non-GSO FSS Systems," Document 4A/TEMP/92 (April 30, 2001).

systems are involved (three or more interfering sources). Avoidance angles, as seen from earth stations or from satellites, can then be defined for any pair of NGSO FSS systems following the procedure described in Appendix 1. As a result it is possible to define, for any point in time, the areas on the ground where each satellite of system A and of system B could be transmitting or receiving without causing unacceptable interference between the two systems.

Teledesic does not endorse the Skybridge 10° trigger for measuring in-line events.[9] Such a trigger, premised entirely on constellation geometry, does not take link parameters into account and, thus, may be underinclusive in that it will miss situations where unacceptable interference does occur or overinclusive in that it will unnecessarily assume the existence of interference events that will not actually occur. Skybridge appears to recognize the limits of its proposal based on its assertion that this trigger is feasible only if coupled with a uniform limitation on power levels of NGSO FSS transmitters.

B. Coordination

As a result of the "in-line" event definition above, the periods of time during which any two systems cannot use the same spectrum without coordination are well defined. Coordination between these two systems will define how they operate during in-line events. Of course, there may be periods of time during which any given system may have to coordinate with more than one system but in any case coordination will still occur through one or more bilateral exercises.

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[9] NPRM ¶ 35.

In Table 1 below we demonstrate how coordination of up to three operational NGSO FSS systems (A, B, and C) might occur in the in-line events model described in Appendix 1. The 7% interference allowance has to be verified for three pairs of systems (AB, AC, BC).

Table 1. Coordination of three NGSO FSS systems.

• 7% allowance is not exceeded for any of the 3 pairs of systems	• No coordination is required and A, B and C can operate over the whole spectrum.
• 7% allowance is exceeded for 1 pair (e.g. AB)	• A and B have to coordinate their operation during this period of time.
• 7% allowance is exceeded for 2 pairs (e.g. AB and AC)	• A and B have to coordinate. • A and C have to coordinate. • Conceptually, the 2 coordinations above can be conducted independently but the results of each coordination will impact the other.
• 7% allowance is exceeded for the 3 pairs	• A and B have to coordinate. • A and C have to coordinate. • B and C have to coordinate. • Conceptually, the 3 coordinations above can be conducted independently but the results of each coordination will impact the other 2.

Similarly, simultaneous operation of four or more systems would be managed through several bilateral coordinations although the results of each coordination could impact other coordinations.

Teledesic generally supports the Commission's proposal that when "operators cannot reach a coordination agreement with a new entrant, then they would be required to establish an in-line event spectrum sharing procedure based on the frequency isolation technique – that is, segmenting the spectrum among the operating systems involved in the predicted specific in-line interference event."[10] However, it is important that this rule be qualified so that such

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10 NPRM ¶ 32.

segmentation would only be necessary in an interference event between current licensees (*i.e.*, any of the seven current applicants that becomes operational). New entrants licensed to operate in future Ku-band processing rounds should be prepared to assume the burden of avoiding in-line events with incumbent systems by employing satellite diversity or homogenous constellations.

II. The Commission's Blanket Licensing Approach for Earth Station Should Not Mandate A Reference Antenna Pattern or Off-Axis e.i.r.p. Density Limits

Teledesic supports the approach to earth station licensing outlined in the NPRM. Blanket licensing is in fact the most practical and efficient means by which to facilitate development of NGSO FSS service in the Ku band as it drastically reduces expense and delay and is necessary in order to permit users to benefit from the transportability of at least some FSS earth stations. The success of blanket licensing is amply demonstrated by the Direct Broadcast Service where ubiquitous deployment of earth stations has allowed maximum service penetration.

The Commission seeks comment on whether it is necessary to specify an NGSO FSS user terminal antenna reference pattern to facilitate intra-service sharing.[11] Teledesic supports the Commission's proposal not to mandate a reference antenna pattern for NGSO FSS user earth stations. Such limitations would unquestionably increase the cost of NGSO FSS user terminals and create additional regulatory burdens without offering significant improvement in system sharing.

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[11] NPRM ¶ 48.

Similarly, Teledesic urges the Commission to avoid burdening NGSO FSS operations with off-axis e.i.r.p. limits.[12] Since on- and off-axis e.i.r.p. values are highly correlated, limiting off-axis e.i.r.p. could actually make sharing more difficult. Generally, the lower a system's on-axis e.i.r.p., the more susceptible it is to interference. A system might comply with off-axis limits by lowering its on-axis e.i.r.p., thereby making it more difficult for other systems to protect it. If applied to NGSO systems, off-axis e.i.r.p. limits could prevent operators from taking advantage of the flexibility inherent in the technology to facilitate sharing by, for example, increasing power.

In addition, it is very difficult to determine the role off-axis e.i.r.p. density limits could play in promoting sharing among NGSO systems. The situation is very different for GSOs, since off axis- e.i.r.p. density at a given angle (e.g. 2°) defines the level of constant uplink interference into a GSO satellite at that particular angle. In the NGSO environment, however, interference varies over time, and depends on factors such as the orbits and number of satellites in each constellation, hand-over strategies, in-line avoidance techniques, and traffic patterns.

Moreover, defining appropriate off-axis e.i.r.p. limits in the NGSO environment would be extremely difficult due to the wide variety of orbit types, orbit heights, and system architectures. In particular, the wide range of path losses associated with NGSO links is of concern. This is not as problematic in the GSO context, where path loss does not vary significantly from link to link. If limits were established for NGSOs, however, the severity of the associated burdens will vary greatly from system to system. It would therefore be difficult

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[12] NPRM ¶ 49.

to impose uniform limits, and it certainly would not make sense to apply the uniform GSO limits in the NGSO context. Given these complexities, the only result that could be predicted if limits were imposed is that NGSO FSS operators would be burdened by the need to deploy large and expensive earth station antennas. The NGSO/NGSO sharing benefits that might justify this burden have not been demonstrated.

CONCLUSION

For the foregoing reasons, Teledesic urges the Commission to adopt an "in-line" events model for spectrum sharing among Ku-band NGSO FSS systems and to adopt blanket licensing for earth stations without mandating a reference antenna pattern or off-axis e.i.r.p. density limits.

Respectfully submitted,

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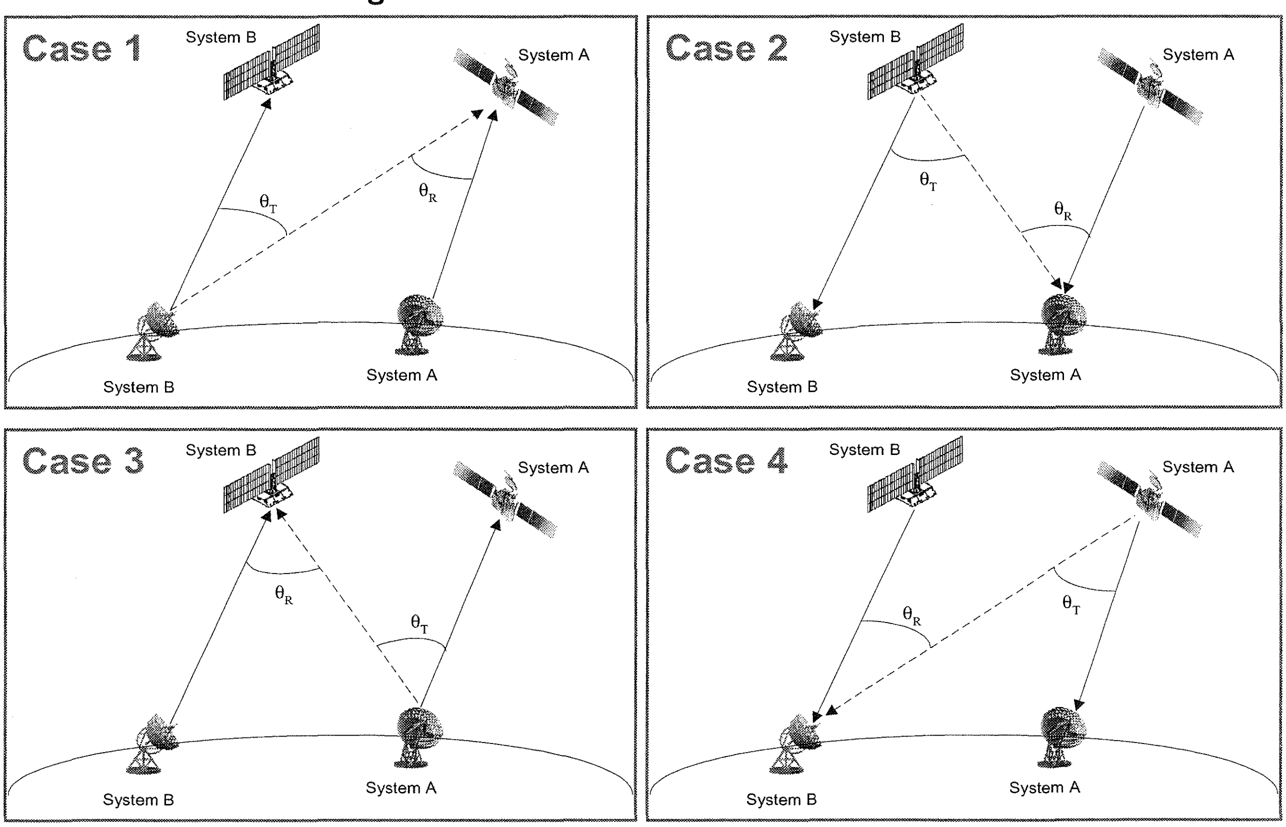
APPENDIX I
Use of Avoidance Angles and ITU-R S.1323 to Define "In-Line" Events

To assess interference between any two non-GSO FSS systems, it is necessary to examine four interference scenarios, derived from the combinations of link direction and which system is the victim system. For the purposes of this discussion, the four interference scenarios may be defined as follows:

- Case 1: System-B interference into System-A uplink
- Case 2: System-B interference into System-A downlink
- Case 3: System-A interference into System-B uplink
- Case 4: System-A interference into System-B downlink

Figure 1 shows these four interference scenarios. The angle θ_T represents the transmit discrimination angle (i.e., the angle off-boresight between the transmitter's signal path and the interference path), and the angle θ_R represents the receive discrimination angle.

Figure 1. Four Interference Scenarios



The amount of interference reduction achieved for a given interference scenario is a function of the transmit and receive antenna gain patterns involved and the avoidance angles employed.

For each of the four cases, it is possible to calculate the amount of angular separation necessary to maintain within acceptable levels the interference due to in-line or near in-line situations using the methodology set forth in ITU-R S.1323. When used just to evaluate whether or not the interference resulting from a given avoidance angle is acceptable, this methodology is relatively straightforward, providing a simple 'pass' or 'fail' evaluation for that interference case. The necessary angular separation to meet the S.1323 requirements essentially involves iterating the avoidance angle used in the interference collection until a passing result is achieved in the evaluation step.

The use of this methodology to verify a given scenario's compliance with S.1323 involves the following steps:

- Determine the degradation threshold value, D_{th}, at which a link outage occurs.
- From link parameters (i.e., clear-sky and heavy-rain link budgets including allocations rain fading and total link margins) and rain fading modeling data, establish a rain degradation (X) probability density function (pdf).
- Generate an interference degradation (Y) pdf from the I/N values collected from a simulation or other analytical approach providing probabilities associated with each I/N value. The relationship between interference degradation and I/N is simply:

  $$Y = 1 + I/N$$

  where all values are in factor (not dB) form.
- Convolve the rain and interference degradation pdf's to generate a total degradation (Z) pdf.
- Determine the acceptable percentage of the total degradation exceeding D_{th}, from the probability of rain degradation exceeding that value and the allowed percentage of total degradation due to interference (10% assumed here):

  $$P_{threshold} = P(X \geq D_{th}) / (1 - 0.1)$$
- A 'pass' or 'fail' evaluation is assigned to this case, based on the truth of the following relationship:

  $$P(Z \geq D_{th}) \leq P_{threshold}$$

The required amount of angular separation is likely to be different for each of the four cases. Therefore, after all interference scenarios are considered, different avoidance angles result.

Based on the above analysis, it is possible to define, for any point in time, the areas on the ground where each satellite of system A and of system B could be transmitting to (or receiving from) without unacceptable interference between the two systems.